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(71) Applicant: **DAVCO MANUFACTURING CORPORATION**
1666 Woodland Drive
Saline Michigan 48176(US)

(72) Inventor: **Davis, Leland Lowell**
5385 Saline-Ann Arbor Road
Saline Michigan 48176(US)

(74) Representative: **Williams, Trevor John et al**
J.A. KEMP & CO. 14 South Square Gray's Inn
London WC1R 5EU(GB)

(54) Fuel delivery system heater.

(57) A heated coupling for a fuel delivery system is provided particularly adapted for use with diesel enging powered vehicles. When the fuel systems are exposed to low ambient temperatures fuel clouding and waxing can occur, which restricts fuel flow to the associated engine. Fuel clogging problems are particularly acute at the fuel tank outlet and in the coupling at the fuel outlet. In accordance with this invention, a heating means such as an electrical heater is provided for increasing the temperature of those fuel clogging areas to reduce wax accumulation. In accordance with an alternate embodiment, a passive heating element is used which is in thermal engagement with an active heating element to conduct heat into the fuel reservoir.

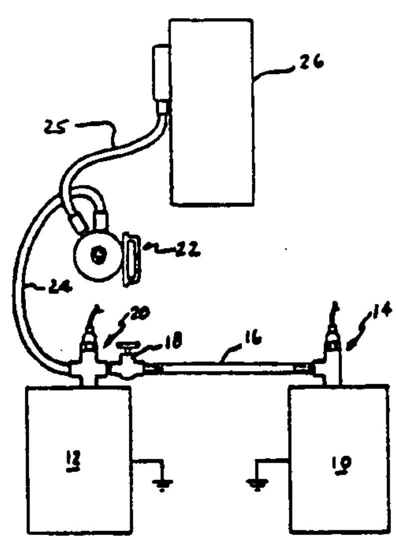

FIG-1

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FUEL DELIVERY SYSTEM HEATER

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates generally to fuel system heaters and more particularly to a fuel delivery system having heater elements for heating fuel adjacent to the discharge opening of a fuel tank.

During cold weather it is often necessary to heat liquid fuels prior to introducing the fuel into a combustion device. Certain fuels and particularly diesel fuel oils tend to become more viscous at low temperatures during the winter months. As temperature decreases, typical diesel fuels tend to form wax or wax like deposits which build up on the inner sides of the fuel tank and also collect on the interior walls of conduits connected to the tanks. If this wax builds up severely, flow to the combustion device is inhibited and often flow out of the tank is restricted or completely stopped by clogging of the fuel lines or tank outlet. In addition to wax accumulations within the tank, wax build-up is often encountered at the fuel discharge fitting where the fuel must make a sharp change in direction. A need therefore arises to provide heat inputs to the fuel system to provide a clear path of transmission of fuel from the storage tank to the associated combustion device.

One solution to inhibiting the formation of wax deposits in a fuel oil storage tank is to provide heating coils within the tank which circulate a hot liquid such as hot water originating from the cooling system of a diesel engine. This approach has the disadvantage that heating occurs only after the enging coolant has reached operating temperature and thus does not provide fuel heating when it is most critically needed, i.e. during start-up. Furthermore, this approach does not satisfactorily address heating requirements at the discharge fitting.

Another means of heating fuel is to provide a resistance heater element immersed into the fuel storage tank for warming the entire tank contents to prevent the formation of wax deposits. During extremely cold weather, however, waxing can still take place near the discharge of the tank and in the discharge fitting, thus clogging the discharge line. More importantly, this approach is extremely inefficient in terms of power input requirements.

The present invention eliminates the necessity for heating the entire fuel tank contents by providing a heater element adjacent or within the tank discharge fitting which ensures that a clear fuel flow path is provided out of the tank. The present invention utilizes a heating element such as a resistance heater positioned centrally within a hollow fuel discharge fitting. The heater according to the present invention can be energized prior to starting the engine to preheat the fuel delivery system or can be continuously energized.

Heat generated by the heater element of this invention is tranferred directly to the fuel in the tank by means of convection in accordance with a first embodiment of the invention, or by a passive heat transfer element in thermal contact with the heater in accordance with alternate embodiments of the invention. The passive heat transfer elements extends through the tank discharge opening and into the tank to provide heat inputs at selected points within the tank.

Various type of passive heat transfer elements may be used with an active element in accordance with this invention. When a heat pipe is used as a passive conduction element, heat is transferred to the opposite end of the heat pipe by means of evaporation and condensation of the working fluid circulating within the heat pipe. Alternately, a solid metal rod can be used as a heat conducting passive element. In this way, heat is transferred by the passive element from the resistance heating element to the fuel in and near the discharge opening of the tank thereby providing a free flow passage for fuel from the tank through the interconnecting conduit and to the engine or an intermediate fuel processing device.

The fuel system heaters according to the present invention are generally positioned within the fuel outlet fitting in the lower side wall of the fuel tank at its bottom. Alternatively, a fuel tank with a top discharge fitting and a drawtube extending into the tank to a position near the bottom may be fitted with a heater in accordance with the present invention. In either application, a resistance heating element may be positioned within the fitting and a passive heating element may be used having one end thermally coupled to the resistance heating element and extending down into the drawtube such that the fuel at the bottom of the drawtube is warmed to reduce wax build-up. To ensure that significant heat is transferred to the opposite end of the passive heat transfer element, an insulating sleeve may be provided around the element for a substantial portion of its length extending into the fuel tank thus precisely delivering heat to selected areas.

Devices according to this invention allow the free flow of fuel from the tank without requiring heating of the entire tank contents, thus providing efficient operation while ensuring that free flow of fuel is maintained. This approach minimizes the energy input requirements by focusing applied heat

to the area most likely to cause flow problems.

Further objects, features, and advantages of the present invention will become apparent when taken in light of the attached drawings and following detailed description and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic top view of one type of fuel system utilizing fuel delivery system heaters according to the present invention;

Figure 2 is an exploded perspective view of the fuel delivery system heater of the present invention;

Figure 3 is a side view and partial cross section of a fuel delivery system heater according to the present invention prior to energization of the heated fitting;

Figure 4 is a partial sectional side view of the fuel delivery system heater shown in Figure 3 after energization of the heated fitting;

Figure 5 is a partial sectional view of a fuel delivery system heater according to the present invention installed in a drawtube in the top of a fuel tank;

Figure 6 is a sectional view taken along the line 6-6 in Figure 5;

Figure 7 is a partial sectional view of a heat pipe connection to a resistance heater in accordance with the present invention;

Figure 8 is a partial sectional view of another coupling method between a heat pipe or thermally conductive rod and a resistance heater in accordance with the present invention;

Figure 9 is a partial perspective view of another method of coupling the heat pipe to the resistance heater in accordance with the present invention; and

Figure 10 is a partial sectional view of the assembly shown in Figure 5 including an insulating sleeve over the heat pipe portion of the fuel delivery system heater in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to Figure 1, the general arrangement of the fuel delivery system utilizing heating elements in accordance with the present invention is shown. Figure 1 is a top view in which fuel tanks 10 and 12 are shown electrically grounded to the chassis of the vehicle. Extending from the discharge opening in the lower side of tank 10 is T-shaped heated fuel delivery system fitting 14. Fitting 14 is connected via conduit 16 and cross over value 18 to conduct fuel to heated fuel delivery system fitting 20 which is connected to the discharge opening in the lower side of tank 12. Fitting 20 is connected to fuel processor 22 via conduit 24, and then via conduit 25 to engine 26.

Fitting 20 is shown in Figure 2 in an exploded view and generally comprising heater element 28 and fitting housing 38 with female threaded ports 29, 31, and 33, and male threaded pipe end 35. Heater element 28 includes resistance heater rod 30 having one end embedded in pipe plug 32. Resistance heater rod 30 is in turn connected electrically to wire 34 with the connection covered by insulating boot 36. Pipe plug 32 is threaded into fitting housing 38 which is connected to the discharge opening of tank 12 by threaded pipe end 35. When installed, resistance rod extends through fitting 38 and extends out of pipe end 35. Fitting 14 is generally similar in construction to fitting 20 except that fitting housing 40 includes two female threaded ports 37 and 39, rather than three as shown in Figure 2. Fitting 14 also includes a modified form of heater element 41 as described below.

The fuel delivery system fitting 14 constructed in accordance with the present invention is shown in Figures 3 and 4 connected to fuel tank 10. Figures 3 and 4 illustrates how the present invention inhibits the formation of wax within the fuel tank. In these figures, a T-shaped fitting housing 40 is shown. A cross over fitting 20 could, however, also be used in this application. As shown in Figure 3, resistance heater rod 41 is embedded in plug 32 and is electrically connected to wire 34. Heater rod 41 is shorter than heater rod 30 and does not extend out of pipe end 35. The electrical connection for heater rod 41 is covered and protected by insulating boot 36 which precludes moisture entry into the fitting and also insulates the connection to prevent short circuiting of wire 34 to chassis ground.

For this embodiment of the invention, the opposite end of resistance heater rod 41 is connected via a straight sleeve coupling 42 to a passive heat transfer element such as a thermally conductive rod or, as shown, a heat pipe 44 which extends through fitting housing 40 and into tank 10 through tank discharge opening 46. A spacer 48 is positioned just inside opening 46 and within pipe end 50. This spacer provides support for heat pipe 44 to prevent vibrations from dislodging the heat pipe from coupling sleeve 42.

In Figure 3, the heater according to the present invention is shown de-energized. In low ambient temperature conditions, way layer 52 forms along the walls 54 of tank 10. As shown in Figure 3, flow of liquid fuel 56 is restricted by the build up of wax 52 around discharge opening 46.

As shown in Figure 4, after heater 14 has been energized for a period of time, the waxing and

clouding in the fuel is reduced in the area of the discharge opening 46, allowing free flow of fuel out of tank 10. Figures 3 and 4 are also representative of operation of fitting 20 utilizing heater 20 without a passive heat transfer member.

Heat pipe 44 shown in Figure 3 and 4 is a thin walled tube containing a working fluid which evaporates and condenses in accordance with the temperature it is subjected to along its length. In fitting 14 as shown in Figures 3 and 4, the heat pipe 44 is butt connected via coupling sleeve 42 to resistance heater rod 41. As current is passed through heater rod 30, the outside surface of the rod is heated. This heat is coupled by conduction to heat pipe 44 which causes the working fluid inside the heat pipe at the connection end to evaporate. A fluid circulation loop is then set up within heat pipe 44 as the fluid at the end of the heat tube that is immersed in the fuel is at a colder temperature than the fluid at the coupling sleeve end of the heat tube. Consequently, the fluid at end 60 condenses, giving up its latent heat of evaporation to the walls of heat pipe 44 and then, via convection, to the wax and fuel surrounding heat pipe end 60. In this manner, heat is efficiently transferred from resistance heater rod 41 to heat pipe end 60 and therefore heats the fuel within tank 10 in the critical areas in and adjacent to fuel tank discharge opening 46.

Several alternative connection schemes by which a thermally conductive rod or heat tube 44 may be connected to resistance heater rod 30 are shown in the drawings. As shown in Figures 1 and 5, a fuel delivery fitting incorporating a passive heat transfer element such as heat pipe 44 according to the present invention may also be implemented in a cross over fitting 20 having the internal construction generally as shown in Figures 3 and 4.

The fuel delivery system heater according to the present invention may also be used with fuel tanks having top discharge connections utilizing a drawtube. In Figure 5, fitting 64 is connected to discharge opening 66 in top tank wall 68. As in the previous embodiments, resistance heater element 41 is embedded into and extends from pipe plug 32, which is in turn threaded into cross over fitting housing 38.

In the embodiment shown in Figure 5, resistance heater element 30 does not extend co-linearly with heat pipe 44 through fitting housing 38. Plug cap 70 is threaded into port 31 and heat pipe 44, having ends 58 and 60, is attached at right angles to and butted against resistance heater rod 41. End 58 of heat pipe 44 is butted against the side of resistance heater rod 41 and fixed against the rod by T-sleeve coupling 62.

The coupling of heat tube 44 to resistance heater rod 41 may be accomplished by several different means, as shown in Figures 7, 8 and 9. For example, end 58 of heat pipe 44 may be collapsed and rolled around resistance heater rod 41 as shown in Figure 7, or alternatively, more of end 58 of heat tube 44 may be rolled so as to wrap around resistance heater rod 41 for several turns as shown in Figure 9. Figure 8 shows strap 72 which is positioned over resistance heater rod 41 and soldered at each end to heat pipe 44 or to a thermally conductive rod as discussed above. Alternatively, a T-sleeve spring metal-clip coupling 62 as shown in Figures 5 and 10 may be utilized. T-sleeve coupling 62 is a spring metal clip which is biased into firm contact with end 58 of heat pipe 44.

Heat pipe 44 extends from fitting housing 38 down into drawtube 74 to a position just short of the end of drawtube 74 which is adjacent the bottom 76 of tank 10. As the heat pipe 44 in this embodiment is generally longer than that shown in Figures 3 and 4, several spacers 78 may be required to provide support for the heat pipe, while at the same time allowing fuel passage through the drawtube 74 and into fitting 38. Spacer 78 may be of various constructions. One such construction is shown in Figure 6 wherein the spacer is a generally disc shaped spring metal plate having a generally circular shape to fit into drawtube 74 and six flutes equally spaced around the perimeter of the disc for fuel passage and a central bore through which heat tube 44 is disposed.

In some embodiments it may be advantageous to more effectively transfer the heat from end 58 of heat pipe 44 to end 60, thereby directing all of the heat to the bottom of the tank around the opening of drawtube 74 near tank bottom 76. This is accomplished as shown in Figure 10 by providing an insulation sleeve 80 along the majority of the length of heat pipe 44. This focuses the heat transferred from end 58 of heat pipe 44 to end 60. Similar results are achieved utilizing a thermally conductive rod in place of heat pipe 44 and having an insulating sleeve 80 on the rod.

The fitting 64 shown in Figure 5 may also be produced similar to that shown in Figures 3 and 4 where resistance heater rod 30 is connected by a butt connection coupling sleeve. In this case resistance heater 30 would be inserted through the upper opening in cross over fitting 38 as opposed to the horizontal opening shown in Figure 5.

The instant invention has been described in an illustrative manner and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation. Obviously many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be

understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

Claims

1. A heated fuel delivery system coupling adapted for use with a fuel tank having a discharge opening, and wherein a conduit is connected to said coupling for directing flow of fuel from said tank to a combustion device, said coupling comprising:
a hollow fitting body having a passage therethrough and at least two fuel flow openings;
active heating means acting as a heat source for warming said fuel within said passage; and
a passive heating means thermally coupled to said active heating means for transferring heat from said active heating means to fuel in said tank adjacent said discharge opening for reducing waxing of said fuel near said discharge opening.

2. The coupling according to Claim 1 wherein said active heating means is an electrical resistance heating rod.

3. The coupling according to Claim 2 wherein said passive heating means is a heat pipe filled with a working fluid for transferring heat by evaporation and condensation of said fluid.

4. The coupling according to Claim 1 wherein said passive heating means comprises a solid metal rod.

5. The coupling according to Claim 1 wherein said active and passive heating means are cylindrical in shape and are butt connected.

6. The coupling according to Claim 1 wherein said active and said passive heating means are cylindrical in shape and are oriented generally perpendicular to one another wherein an end of said passive heating means contacts said active heating means along its length.

7. The coupling according to Claim 6 wherein said active and passive heating means are connected by a metal attaching clip.

8. The coupling according to Claim 6 wherein said active and passive heating means are connected by wrapping an end of said passive heating means around said active heating means.

9. The coupling according to Claim 1 wherein said passive heating means is cylindrical in shape and an insulating sleeve surrounds a portion of said passive heating means.

10. A heated fuel delivery system coupling adapted for use with a fuel tank having a discharge opening, and wherein a conduit is connected to said coupling for directing flow of fuel from said tank to a combustion device, said coupling comprising:
a hollow conduit fitting body having a passage therethrough and at least two fuel flow openings;
electrical heating means attached to and extending into said body through at least one of said openings;
an insulated electrical conductor; and
connecting means joining said conductor to said electrical heating means for directing electrical current to said heating means, said heating means warming the fuel within said fitting body.

11. The coupling according to Claim 10 wherein said electrical heating means is in the form of an elongated resistance heating rod.

12. The coupling according to Claim 11 wherein said heating means further comprises a passive heat transfer means connected to said resistance heating rod for transferring heat from said rod to the fuel in the interior of said tank.

13. The coupling according to Claim 12 wherein said passive heat transfer means is a heat pipe.

14. The coupling according to Claim 13 wherein said heat pipe has a flattened end, said flattened end being wrapped around said rod to secure said heat pipe to said rod and to conduct heat from said rod to said heat pipe.

15. The coupling according to Claim 12 wherein said passive heat transfer means is fastened to said rod by a metal spring clip fixed to one end of said passive heat transfer means.

16. The coupling according to Claim 13 wherein said heat pipe further comprises an insulating sleeve surrounding said heat pipe along a major portion of the length of said heat pipe so as to direct heat transferred from said heating rod to the uninsulated portion of said heat pipe.

17. The coupling according to Claim 13 further including a spring spacer means positioned between said fitting and said tube providing support to said heat pipe.

18. The coupling according to Claim 17 wherein said spring spacer means comprises a spring disc having a central bore for passage of said heat pipe therethrough and an outer edge having a plurality of flutes therein for passage of fuel therethrough when said heat pipe with said spacer mounted thereon is positioned within said conduit fitting body.

19. The coupling according to Claim 13 further including a drawtube having two ends, one end attached to said tank adjacent said discharge opening, the other end of said drawtube projecting into said tank, and said passive heat transfer means extending through said drawtube whereby heat is directed to the fuel at the other end of said drawtube.

20. A heated fuel delivery system coupling adapted to use with a fuel tank having a discharge opening, and wherein a conduit is connected to said coupling for directing flow of fuel from said tank to a combustion device, said coupling comprising:
a hollow conduit fitting body having a passage therethrough and at least two fuel flow openings;
an electrical heating rod acting as a heat source attached to and extending into said body through at least one of said openings;
a thermally passive heating means thermally coupled to said heating rod and extending through one of said openings and through said tank discharge opening into said tank; and
connecting means joining said heating rod to said passive heating means for transferring heat to said passive member, said passive heating means directing said thermal energy to the fuel in and adjacent said discharge opening thereby reducing waxing of the fuel and ensuring free flow of the fuel from said tank through the conduit to the combustion device.

21. The coupling according to Claim 20 wherein the passive member further comprises a heat pipe having a thin thermally conductive wall and a working fluid for transferring heat by evaporation and condensation from one end of said heat pipe to the other.

22. The coupling according to Claim 21 wherein said heat tube further comprises an insulating sleeve surrounding said heat pipe along the major portion of the length of said heat pipe so as to direct heat transferred from the heating rod to the uninsulated portion of said heat pipe.

23. The coupling according to Claim 21 further including spacer means positioned between said fitting and said heat pipe to provide support for said heat pipe.

24. The coupling according to Claim 23 wherein said spacer means comprises a spring disk having a central bore for passage of said heat pipe therethrough and an outer edge having a plurality of flutes therein for passage of fuel therethrough one said heat pipe with said spacer mounted therecn is positioned within said conduit fitting body.

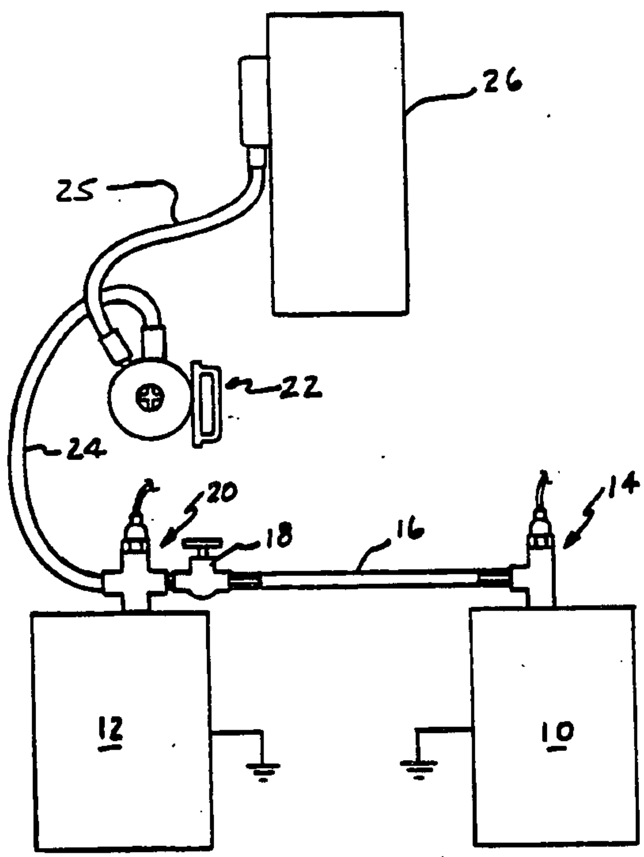

FIG-1

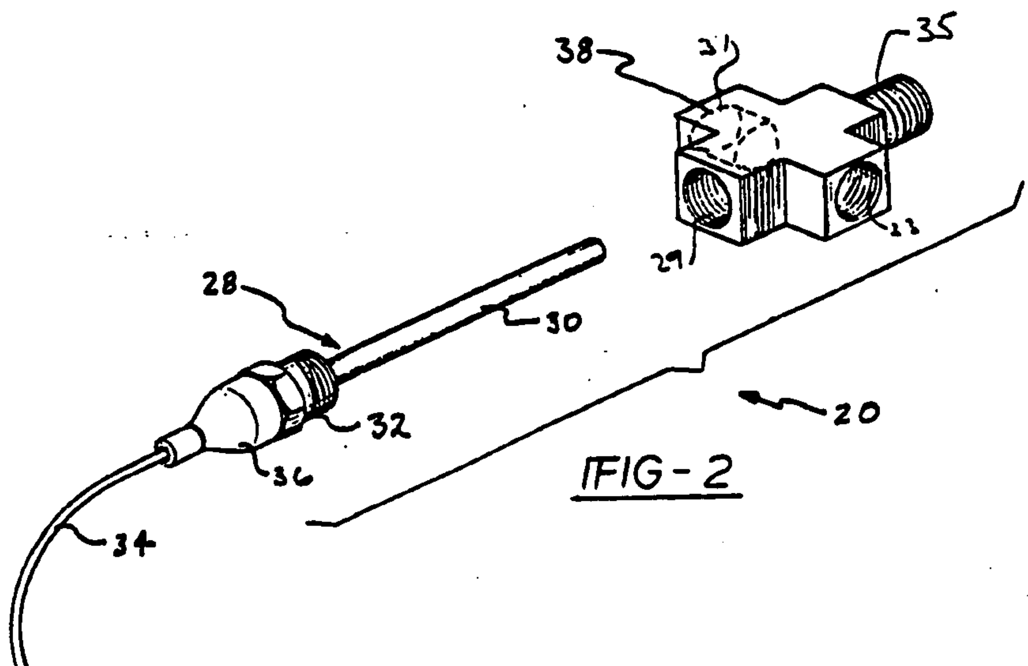

FIG-2

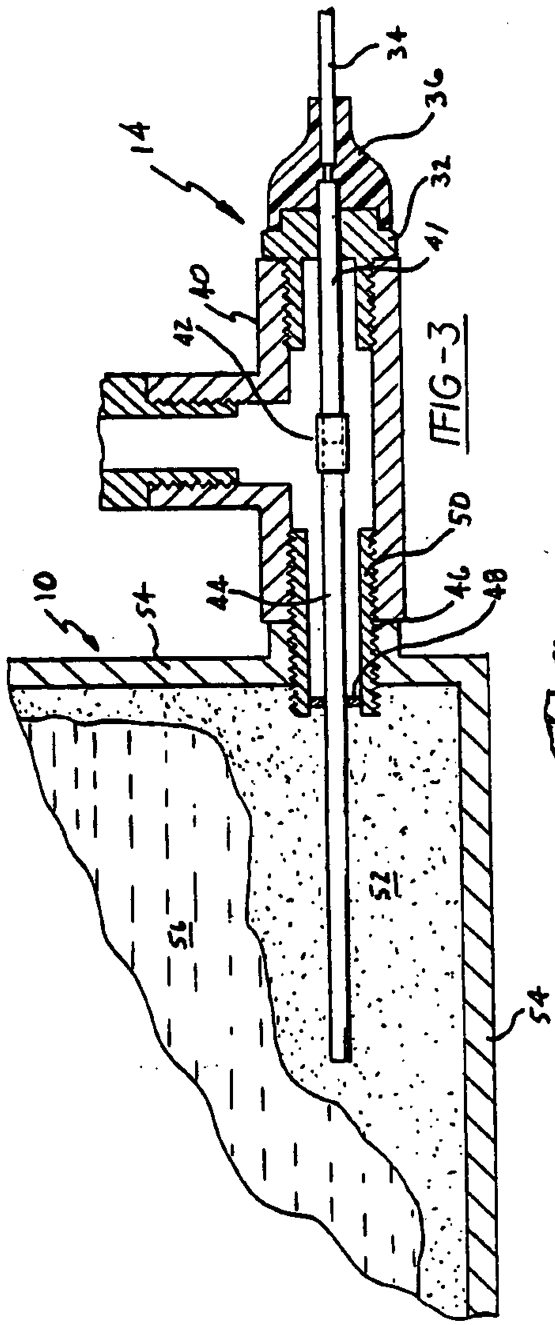
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FIG-3

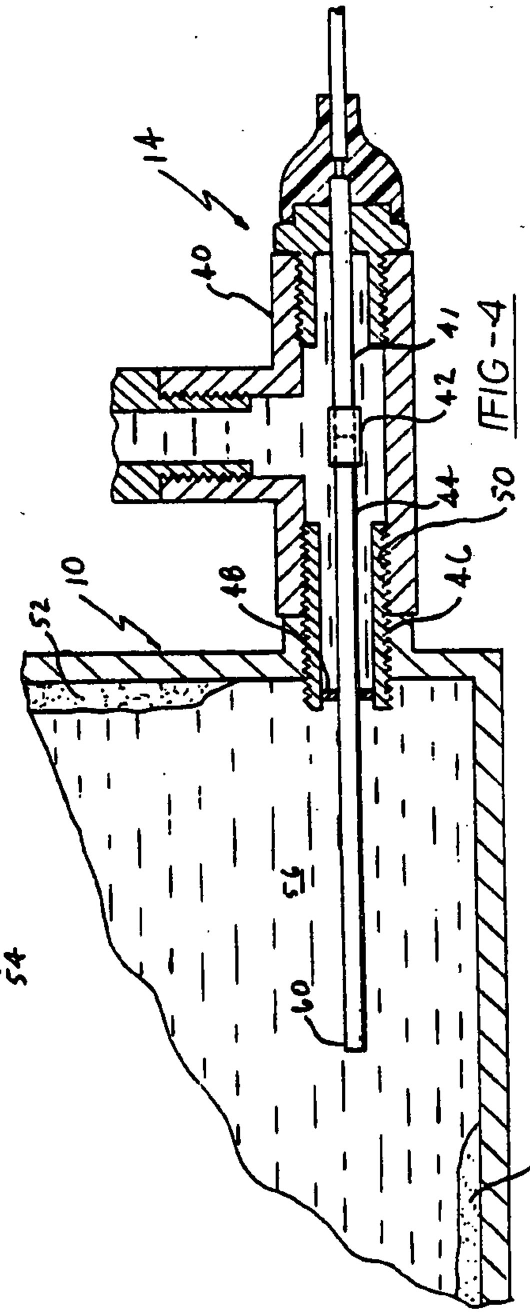
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FIG-4

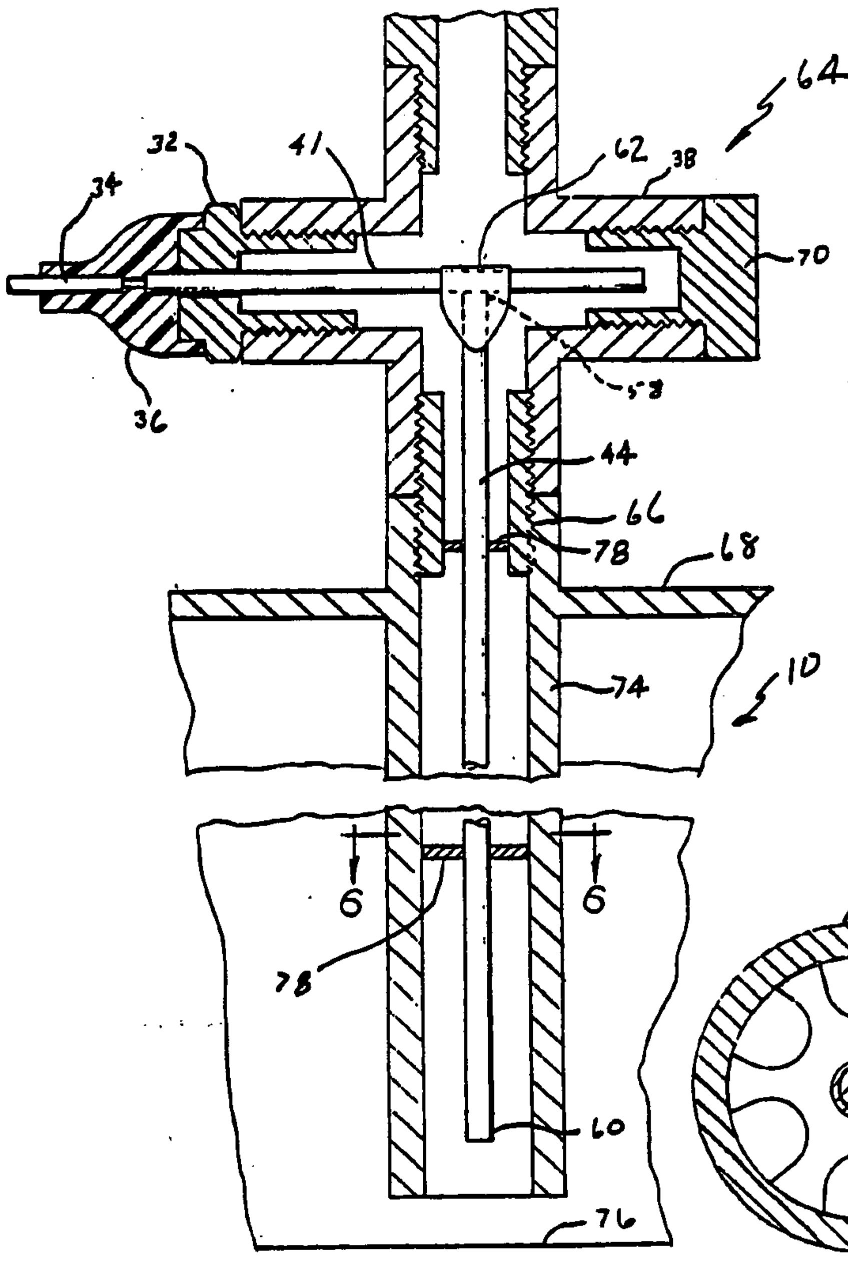


FIG - 5

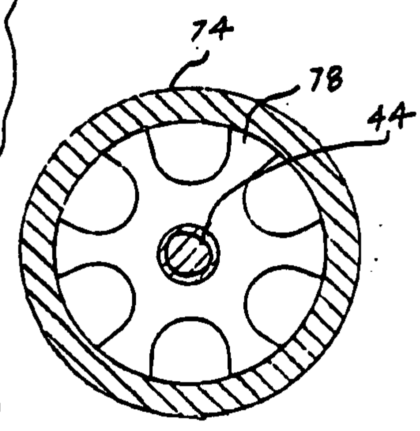
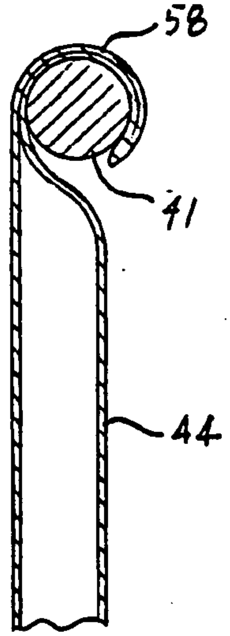


FIG - 6



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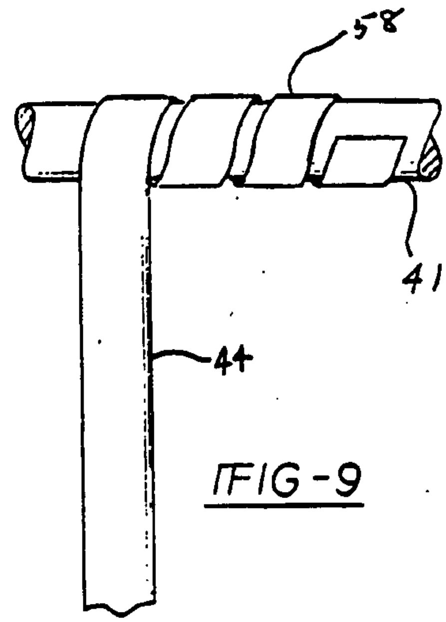

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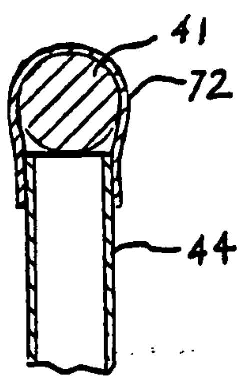

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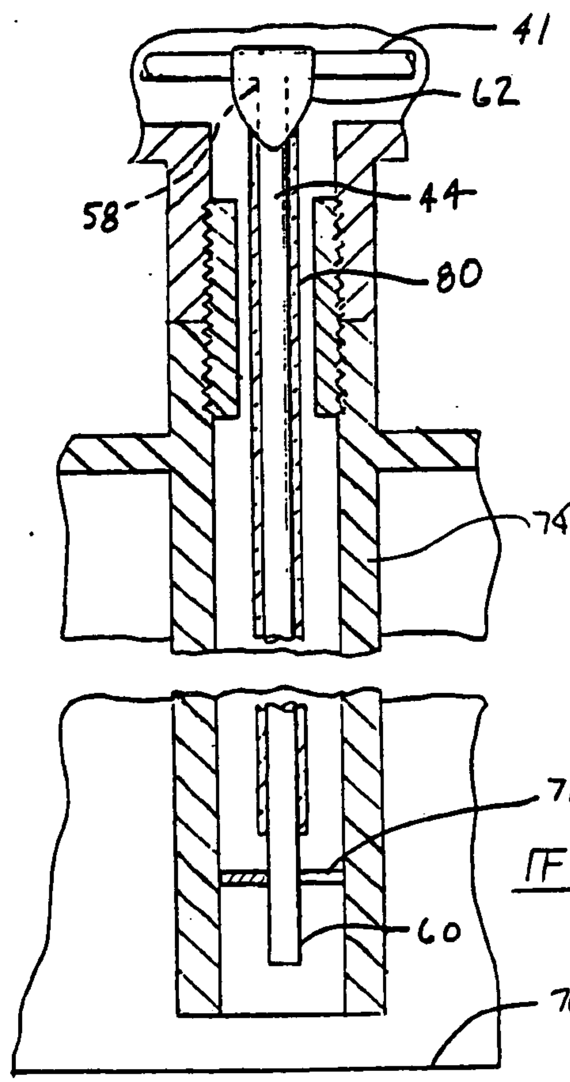

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